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Technological Innovation in Humanitarian Aid Allocation during Epidemic Situations

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With an application in the development of a real-time case reporting platform via SMS and web

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The rise of the recent Ebola epidemic as well as recurring epidemics in the developing world such as malaria, Chikugunya virus, Corona Virus, exposes shortcomings in the status quo of humanitarian aid. Namely that current humanitarian aid processes are unable to get resources to those who need it when and where this aid is needed most. In this paper, I explore potential points along the entire value chain of humanitarian aid where current technologies are already being utilized to alleviate inefficiencies, explore future technologies and techniques that hold promise for further improvements along the value chain, describe the development process of my own SMS-based epidemic tracker, as well as discuss some of the limitations and barriers to entry of the adoption of this new technology.

The Humanitarian Aid Value Chain

The humanitarian aid value chain can be broadly broken down into component segments:

1. Fundraising
2. Allocation of Funding
3. Deployment and Delivery of Resources

Expanding laterally across these segments is the dissemination of information about the spread of a disease or epidemic, to key stakeholders including international governing bodies, local and national governments, non-government organizations (NGOs), local doctors and aid workers, and the general public.

Fundraising

Fundraising encompasses the ability of international foundations, international organizations, and other key stakeholders to raise necessary funds to deploy aid in an effected area. This fundraising occurs on the million and billion dollar range, with Medecins Sans Frontieres provisioning a budget of €113M ($138M) for 2014 and 2015 on Ebola relief[1] and Obama's recent declaration of $6B to Ebola relief.

Largest Problem Area: Lack of Transparency

From a donor's perspective, the largest problem area in fundraising is the lack of transparency in the allocation of fundraised resources by private and public organizations. Donors are unsure about where their fundraised money is going and how

[1] http://www.doctorswithoutborders.org/our-work/medical-issues/ebola

efficiently it is being spent on the ground. Since much of the onus of determining whether or not an organization is efficiently allocating its funding is placed on the donor, this can be a point of paralysis for donors. In response, donors will either choose not to donate at all or allocate their money to large and more reputable charity funds such as MSF or American Red Cross, regardless or whether or not these large umbrella organizations are effective at tackling the specific disease at hand. Interesting, both of these large organization have failed to create fundraising for specific epidemics.

A spokesperson for the American Red Cross, which frequently creates specific fundraising pages following natural disasters such as the Haiti earthquake, has previously stated that "American Red Cross creates targeted fundraising pages when there's enough interest in a particular cause,"[2] implying that there has simply not been sufficient interest for a specific Ebola campaign. There seems to be a psychological underpinning for the difference in donor responses to epidemics versus sudden, occurrence based disasters like a devastating earthquake, namely "when people see a disaster happen slowly over time — especially a disease outbreak - they're usually less likely to open up their wallets."[3] American Red Cross does allow donors to specify where they want their donation to go, however, through a separate online form.

MSF, on the other hand, cites lack of flexibility and speed considerations as the largest reasons for their decision not to generate specific fundraising campaigns or take earmarked donations for epidemics. Sophia Delaunay, executive director of MSF, states "We want to be able to have sufficient cash flow to respond to an emergency right away and not wait to have earmarked funding to come," further highlighting that funding is not their largest concern but rather lack of human resources, supplies, and resources in treatment centers.

Ultimately, for the general public, assessing the efficiency and trustworthiness of smaller, more specialized organizations may simple be too great of a hassle compared to donating broadly to larger, more established organizations, even if their donations can not be earmarked for the relief of the specific epidemic in question, but is rather given to the organization as a whole for all relief efforts. This results in a large pooling of capital fundraised from the general public within a small circle of very well-known charitable organizations; the general public then trusts these expansive charitable organizations to allocate this funding as they see fit, potentially to the epidemic at hand or perhaps to another cause covered by that organization's umbrella.

[2] http://abcnews.go.com/Health/fundraiser-fight-ebola/story?id=25091795
[3] http://abcnews.go.com/Health/fundraiser-fight-ebola/story?id=25091795

Technological Applications

The largest technological application in fundraising have been the ability to crowdsource donations from the general public and the ability to create viral campaigns over social media. Large organizations are able to solicit donations online and campaigns over Facebook and Twitter offer social pressure that can increase awareness and increase donations through social nodes. A more quantitative approach to marketing of donation campaigns includes A/B testing and the ability to test the response of the general public to two versions of a donation campaign in a controlled experiment to determine the efficacy of either campaign in eliciting a "conversion" or an actual donation by the viewer of the campaign. New data driven approaches to marketing are being taken from the commercial sphere and applied to the non-profit sphere with great success. A case study of a particularly successful application of viral campaigns to philanthropy includes the ALS Ice Bucket Challenge, in which people posted videos of themselves dumping ice water on themselves and nominated their friends to do the same or donate to the ALS Association. In total, there were over 2.4 million challenge related videos posted to Facebook[4]. The campaign raised over $100 million for the ALS Association, or an increase of 3,500% compared to the same period in the prior year[5].

While these new data driven, social/viral approaches to marketing have achieved great success when transported from the commercial sphere to the non-profit, they do not come without costs. Namely, marketing diverts funds otherwise used for aid related functions to consulting, design, and implementation of marketing campaigns. There is large disagreement about the appropriate level of funding that should be allocated to fundraising as opposed to aid-specific allocations. CharityWatch, an organization that offers ratings of non-profit organizations on their transparency and effectiveness based on established benchmarks states that "Highly efficient charities…should spend no more than $25 to raise $100"[6]. Software that offers A/B testing functionality as well as consulting firms that specialize in online campaigns require substantial amounts of funding without necessarily guaranteeing better outcomes. For example, the ability to predict virality of content remains an extremely nascent field: it is not clear or apparent what makes content go viral and the success of a campaign can often depend on the fickle participation and buy-in of high profile celebrities and linkers within social networks. While content may have characteristics that give it the potential of becoming

[4] http://www.bbc.com/news/magazine-29013707
[5] http://www.ibtimes.com/how-much-money-has-als-ice-bucket-challenge-raised-more-100-million-has-poured-where-will-1677980
[6] http://www.charitywatch.org/hottopics/ebola_relief.html

viral, these in no way guarantee that content will become viral. Further, viral content suffers from being extremely hit-driven, either content is a complete home run or it gets nowhere, and once content becomes viral, positive feedback loops through exposure on social media and news outlets, can increase the spread of the content even more.

Another application of technology is in the systemization of directly comparable information about various non-profit organizations. In general, non-profits suffer from lack of transparency about how their funds are allocated and how efficiency their capital is deployed, leading to lack of trust among potential donors. Exacerbating this problem is the fact that disclosed information about capital efficiency is offered from disparate sources and websites and not systematized in a way that allows them to be easily compared for the general public. As a result, even if information is disclosed, few have the patience to actually find information from different websites and sift through, comparing line item by line item the efficiency of different organizations. There are huge applications of technology in closing this knowledge gap for potential donors, by systematizing the presentation of data offered from these organizations into XML formats or APIs that are consistent between organizations, centralizing and compiling this information into one location through web scraping, and presenting this information in visually-appealing, easy-to-digest formats accessible to the general public.

Allocation of Funding

Allocation of funding refers to the ability of organizations to determine the manner in which capital should be distributed, both geographically (which effected regions) and categorically (what the funding should be spent on).

Largest Problem Areas: Coordination between Groups and Lack of Flexibility

The complexity in the number of organizations working on a specific epidemic results in the increased complexity of coordinating between groups. These difficulties manifest themselves in overlap in funding allocation and the inability to achieve economies of scale through combined efforts. Budgets of large organizations and international governing bodies are extremely difficult to coordinate, both because organizations often do not submit their budgets at the same time of the year, nor are the councils that develop budgets geographically proximal. This presents an added problem when organizations have potentially overlapping missions or a lack of a clear mandate in where in the value chain of humanitarian aid they should focus their budget on. For example, in the simple example of two organizations, for example, the MSF and the UN both building healthcare facilities in a certain geographic region, there should both be coordination in the quantity and location of these facilities to prevent overlap as well as coordination with supply and labor contracts negotiated to build these facilities, in order to achieve economies of scale in the cost of purchasing and transporting supplies and labor, building and establishing these facilities. Add in a couple dozen additional organizations all submitting budgets on different timelines and negotiating contracts with different subcontractors and the coordination effort becomes exponentially more complex. Conflicts between politically or socially driven organizations with different affiliations and leanings further complicate the problem by decreasing transparency in information and limiting the amount of bundling in resource purchasing and resource delivery that can happen.

As an added problem, decisions of funding allocation, once made, are hard to modify due to the size of these non-profit and international organizations and the inertia of paperwork, information lag, and implementation lag. In MSF's annual Ebola report, the organization highlights that "Many international actors seem unable to adapt quickly enough to a rapidly-changing situation. The result of this is that resources are being allocated to activities that are no longer appropriate to the situation. In Monrovia, Liberia, for example, more case management facilities are being built despite adequate isolation capacities and a drop in cases in the capital. All actors involved in the response – MSF included – must take a flexible approach and allocate resources according to the most pressing needs at any given time and place" [7]. MSF refers to this situation as a "double failure" in which response is both slow in its first instance and ill to adapt thereafter.

Technological Applications

Personally, I think the biggest applications of technology in allocation of funding is machine learning and big data applications to (1) fraud/misappropriation of funds detection, (2) algorithmic determination of overlaps in budget proposals between organizations, (3) statistically driven predictions of how much aid will be needed where, (4) dynamical, automated budget reallocation based on real-time field data.

Given large sets of data on funding allocation, techniques are currently being employed that can analyse transactions for indications of fraud. Palantir, for example, has a large arm analysing government and non-profit sector data and flagging instances likely to indicate fraud based on suspicious indicators. While there is still a need for human intervention and examination of these flagged instances, large-scale data

[7] http://www.msf.org.uk/article/ebola-international-response-to-ebola-risks-becoming-a-double-failure

analytics allow us to sift through significantly more data and identify suspicious patterns faster and with greater consistency than human labor.

Ultimately, the pinnacle in terms of efficiency in funding allocation determination will be complete transparency in real-time of allocation by large organizations and the ability to dynamically shift allocations based on real-time data streams from the field. The largest barrier to this efficient system is the systemization of data and lack of access to clean real-time information. Data from different organizations as well as the budget allocations of different organizations is far from systematized and not publically available to developers through APIs. The only way we can open that data up to machine analysis is through intense transformation of that data to a systematized, consistent format, across organizations. Further, dynamic fund allocation relies on infrastructure that makes real-time, trustworthy data from the field possible. Currently, the lack of communication infrastructure and a verified network of sources on the field offering systematized information of the same format makes information difficult to compile and thus impossible to garner insights from.

Deployment and Delivery of Resources

The deployment and delivery of resources refers to the allocation and delivery of treatments, supplies, and human resources to effected regions. This spans both the decision making of how many resources are necessary as well as determination of the most cost and time effect way to deliver these resources to the field.

Largest Problems: Mismatch between Human Resources and Supplies

In MSF's Ebola report, MSF names staffing one of the most serious "bottlenecks" of international aid. In fact, when Australia offered almost $2M to MSF to fight Ebola, MSF refused to accept it, stating that "[w]hat was urgently needed from rich Western countries…was not more money but doctors and nurses"[8]. The lack of trained professionals on the ground stems from the difficulty of finding international professionals willing to travel to dangerous areas as well as the difficulty of training local professionals. In contrast to the overwhelming number of people to volunteered following the Haiti earthquake, it has been difficult to recruit volunteers for the fight against Ebola, given the dangerous nature of the disease and the length of time that volunteers are required to put in. While volunteering in Haiti could be as little as a two week stint, volunteering to fight Ebola requires a commitment of at least six weeks on the

[8] http://www.huffingtonpost.com/2014/10/24/ebola-doctors-shortage_n_6043286.html

ground as well as another three weeks to avoid spreading the disease[9]. MSF points to a fundamental mismatch between funding allocation to establish infrastructure and the number of available qualified staff to run them: “Though all three of the worst-hit countries have received some assistance from foreign governments, these actors have focused primarily on financing and/or building Ebola case management facilities, leaving staffing them up to NGOs and local healthcare staff who do not have the expertise to do so. Training people to safely operate Ebola case management facilities and carry out other necessary activities takes weeks of theoretical and hands-on training”. Often times, civilian volunteers, while well meaning, actually hinder progress of professionals. Due to their lack of skills and training, they can become a liability on the field rather than being helpful.

On the resources side of the equation, the current system for determining what resources are needed where is currently fragmented by individual organizations or local governments. These doctors on the field communicate via satellite phone to coordinators on the status and availability of resources in a certain area, as well as request refills. However, the inability to share this resource delivery system across organizations is a hindrance to progress. While International umbrella organizations, like the WHO and the UN, have the breadth of influence, they often lack the actual heavy lifting power to coordinate large resource pooling systems. Further, resources are often not efficiently deployed between non-profit organizations with their own political or social causes and leanings. For example, non-profit organizations with a religious leaning or special interest may be unwilling to work with other non-profit organizations of a different interest, leading to inefficiencies in pooling resources as well as inefficiency in coordinating shipments of supplies and other resources.

Technological Applications

The greatest place for technological application in this part of the value chain is (1) the real-time determination of what resources are needed where, (2) predictive analytics of pre-emptive resource allocation, and (3) open-source determination of efficient delivery routes. As before, systematized data and shared communication infrastructure is crucial to pooling of resource shipments between different organizations. Once in place, however, this infrastructure would significantly improve the resource allocation process during epidemic situations and allow for real-time updates from a verified network of doctors and mobile clinics. Inventory management

[9] http://www.huffingtonpost.com/2014/10/24/ebola-doctors-shortage_n_6043286.html

systems that have already been implemented by point-of-sale (POS) systems in the small and medium sized businesses through Square and Quickbooks can similarly be applied on a large-scale to the determination of resource allocation in epidemic situations. Statistical and big data methods can also be applied to dynamically predict necessary resources for initial resource deployment to new regions based on the number of mobile clinics, number of potential cases, and other factors of the region itself.

Lastly, one incredible application of technology to resource allocation recently has been open-source mapping of local roads, paths, and bridges in order to determine the most efficient ground-based delivery routes for human resources and supplies into a region. This effort has been pushed by a collaboration between MSF, mapping NGO cartONG, and open-source map platform OpenStreetMap, which allows for the crowdsourcing of street names, building names, and potential Ebola cases in what originally was an information vacuum. Sylvie de Laborderie of cartONG describes this information vacuum, recalling "The map showed two roads maybe – nothing, nothing" but through crowdsourcing, volunteers from all over the world were able to add over 100,000 buildings based on satellite images of the area, in a mere 12 hours[10]. The system allows for the determination of the most efficient delivery routes as well as building information for humanitarian aid workers attempting to track cases of the epidemic from their origin to where they spread on a door-to-door basis within villages.

Information Dissemination

Spanning these portions of the value chain is the huge question of how information is transferred between key stakeholders, from doctors on the field to the laboratory to the general public and to the governmental and non-governmental organizations.

Case Reporting

The traditional propagation of suspected cases to local officials, national officials, and then to international organizations is shockingly primitive. Leisha Nolen, a representative of the CDC describes an encounter with potential case tracking by local officials: "[when she] asked to see the tally of suspected Ebola cases, [t]he officials pulled out a thick stack of papers. Each handwritten sheet represented a likely case, many of which had yet to be officially reported."[11] Local officials were simply unable to handle the

[10] http://www.newscientist.com/article/mg22229644.400-online-army-helps-map-guineas-ebola-outbreak.html#.VJNp9MAAEA
[11] http://www.washingtonpost.com/sf/national/2014/10/04/how-ebola-sped-out-of-control/

influx of potential cases, track their origin and potential future headings. The failure of this propagation of case reporting through local government officials and regional offices of international organizations is highlighted by the fatally late response of the WHO in declaring the Ebola epidemic a global emergency, over 4.5 months into the epidemic, at which point the cumulative number of cases already exceeded 1,500 and the death toll stood at 932[12].

Technological Applications

As opposed to waiting for local officials to propagate information about potential cases of diseases via paper and pen, webscraping based platforms allow doctors and international organizations to constantly monitor social media and local news outlets for patterns and trends in epidemics. One recent platform, HealthMap, a free platform based out of the Boston Children's Hospital which algorithmically follows media outlets for coverage on epidemics acquired wide-spread media attention after it was able to recognize the a haemorrhagic fever in Guinea more than a week before WHO officially reported on the Ebola outbreak on March 24th[13]. The platform works by automatically scraping, every hour, hundreds of thousands of online sources based on keyword searches, local news outlets, social media, RSS feeds, and APIs, and sorting these sources based on geographic location and disease relieved by the source[14]. John Brownstein, co-founder of the HealthMap project, who I had the pleasure of conversing with, started the project over 6 years ago and recalls actually having very little initial success in getting adoption by the CDC and WHO, as the organizations are generally slow to adopt new technology. Now, CDC and WHO are both avid users of the platform. His platform operates in a world of incomplete information, sidestepping the bureaucracy and red tape of traditional case detection propagation by leveraging the large amount of data freely available on the web. The platform is expanding into more sources of data, more languages, and is also determining more specific ways of categorizing cases on the basis of resistance and substrain why sorting out the noise of vast amounts of data scraped from the web.

[12] http://www.washingtonpost.com/news/morning-mix/wp/2014/08/08/who-declares-international-health-emergency-for-ebola/

[13] http://www.bostonglobe.com/lifestyle/health-wellness/2014/08/07/digital-health-map-tracks-new-cases-ebola-virus-real-time/DjPXtj8O7R81wij7dhDkIN/story.html

[14] http://www.techrepublic.com/article/how-an-algorithm-detected-the-ebola-outbreak-a-week-early-and-what-it-could-do-next/

Awareness of the Public

One of the greatest problems preventing effective humanitarian aid in an epidemic situation is public misinformation about how to respond appropriately to disease cases and the resulting resistance of locals to foreign humanitarian efforts. In some rural areas, animist beliefs and other spiritual beliefs still dominate, leading some locals to "associat[e] Ebola with witchcraft and sorcery, or brand it an evil brought in by foreigners" [15]. Reuters describes how, "[i]n Liberia's Lofa County, health workers who visited two communities, Bolongoidu and Sarkonnedu in Voinjama district, were intercepted by village elders and a mob of angry residents" and told to leave because "Ebola does not exist." Adding on to the problem is the disposal of contaminated cadavers in body bags by foreign humanitarian aid workers. This practice, meant to reduce risks of transmission of the disease, is at odds with traditional burial practices, which demand that family members touch and wash the contaminated cadavers of the deceased in a sign of respect to the dead. There is also distrust of treatment facilities and an avoidance of them, since villagers "see people arrive [at the treatment centers] more or less OK and then they die there" [16], causing cases to go untreated and uncontained. Ultimately, the situation has resulted in significant distrust between locals and foreign aid workers, which hinders the efforts to contain the disease.

Technological Applications

While not applied directly in the Ebola epidemic, there have been enormous efforts to increase dissemination of health information through mobile devices ("mHealth model"). A recent collaboration between the US Agency of International Development, the mHealth Alliance, and the UN Foundation delivers health messages via SMS to expecting mothers in Bangladesh, South Africa, and India in order to improve infant and maternal mortality rates. Multinational corporations have also been active in this effort: Vodafone released a platform in 2013 that allowed Vodafone customers to dial a short number in order to speak directly to a doctor or nurse for telehealth advice for only one Ghanaian pesewa. While the system is only available in certain hours of the day, it is available daily at a very cheap rate, offering medical advice and information to the general public[17]. According to the UN's International Telecommunications Union (ITU), developing countries have an 89% mobile penetration rates. These countries also have the highest mobile growth rates in the world, suggesting that mobile technology

[15] http://uk.reuters.com/article/2014/07/13/health-ebola-westafrica-idUKL6N0PO0V220140713
[16] http://uk.reuters.com/article/2014/07/13/health-ebola-westafrica-idUKL6N0PO0V220140713
[17] http://vibeghana.com/2013/09/25/vodafone-ceo-officially-unveils-mobile-healthcare/

may be a crucial outlet to reaching the general public and disseminate knowledge to it. At the United Nations Commission on the Status of Women, humanitarian aid workers described the powerful dissemination of knowledge that occurred through podcast-like audio recordings of news and health information on basic feature phones. Villagers would download these recordings and congregate and listen to the recordings in order to gain access to information about the world and risk factors around them.

Real-time SMS-based Disease Tracker

After surveying technological applications along the humanitarian aid value chain, I wanted to examine more closely the applications of technology into case reporting aspect of information dissemination and built my own real-time SMS-based epidemic tracking platform. The platform is inspired and motivated by prior research on the use of human migration data to predict epidemic outbreaks but made practical through its application on real-time data.

In 2012, Amy Wesolowski of Carnegie Mellon, et. al, used spatial mobile phone data to map the spread of malaria due to human travel in Kenya. This article, published in Science, offered insights into the sources and sinks of imported infections due to human travel and the directional movement of the parasite from Lake Victoria and other coastal cities to Nairobi. This study offers a proof-of-concept for the use of mobile data in order to predict the spread of diseases. However, the study was limited due to its heavily reliance on all available mobile data as well as the fact that it worked with data from the malaria epidemic three years prior to the study. Hence, while the article is extremely elucidating from a research perspective, a system that worked in real-time would have significantly more practical significance.

As a potential real-world application of this research, I wanted to extend this study and build a platform that would offer real-time SMS-based disease tracking. The system was built with a MongoDB backend using Meteor.js, a flexible Javascript framework, with Twilio and Google Maps integration. The webapp features a heatmap that would allow non-profits, doctors, and the general public to track the spread of suspected cases in real-time (Appendix 1). Cases can be reported in real-time both through the online portal (accessible on mobile: Appendix 2) and over SMS (Appendix 3) by a verified network of doctors, mobile clinics, and humanitarian aid workers. The model was expanded to include information about strain and drug resistance, in order to predict the appropriate drugs to use on patients and help doctors coordinate their efforts to reduce the chance of drug resistance. This model could also be easily expanded to other diseases including tuberculosis and help in the coordination of other relief efforts including the delivery of contraceptives, HIV prophylaxis, and vaccines to areas that needed them the most.

Existing Features

The current model includes the following features:

- User accounts
  - Users are able to sign in online and report cases
  - Users are able to view a heatmap representation of the cases reported to the system
  - Users are also able to report cases via text message and have their cases submit online
  - Users are able to star cases that they find interesting and leave comments
- Cases
  - Location (String)
  - Latitude and Longitude (Geographic coordinates, automatically generated given an address or city to protect privacy of information)
  - Strain (String)
  - Drug Resistance (String)
  - Treatment (String)
  - Notes (String)
  - Number of Cases (Integer)
  - Cases are saved persistently in a central MongoDB database and are used to populate the heatmap
- Heatmap and Listing of Most Recent Cases (Appendix 3)
  - A heatmap generated in Google Maps that represents the density of cases reported in specific regions
  - List of most recent cases on the main page

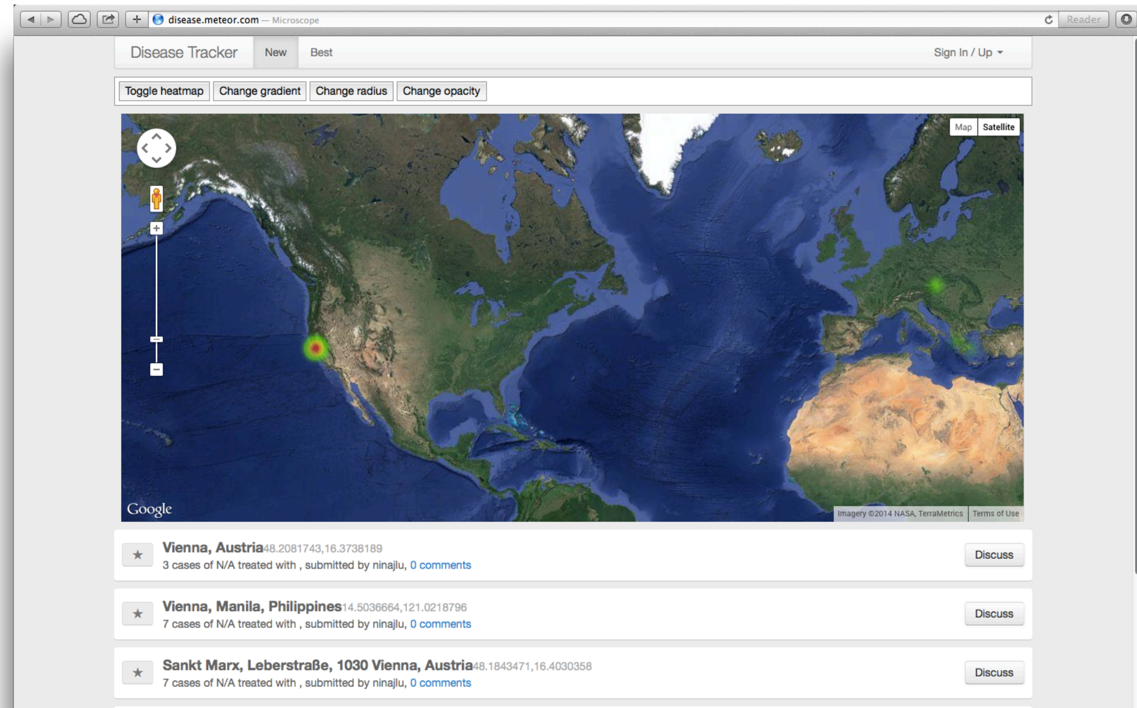
Future Improvements and Barriers to Adoption

While the platform is functional, a vast majority of the value of the system will come from the actual users that populate the system and the data analytics that can occur on the data after it has been inputted into the system. The hugest barrier to entry in this goal is the inability to get CDC/WHO buy-in as well as the buy-in of other organizations. The CDC and WHO have generally been slow and reluctant to adopt new technology due to the difficult of integrating it into their existing complex workflows as well as the fact that day-to-day operations on the ground occupy a significant amount of their time and energy. Cooperation between organizations is difficult to garner, especially given the conflicting leanings of these organizations toward religious groups or other special interests. The platform, at the end of the day though, is only as powerful as the data that is inputted into the system.

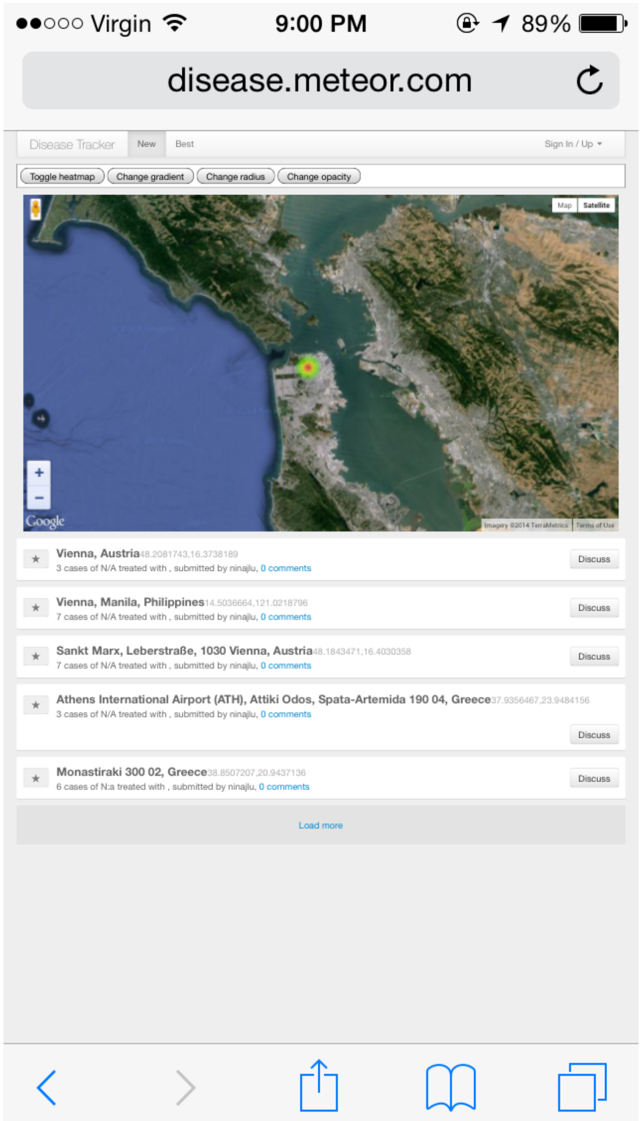
The biggest feature I would like to see is the overlaying of human migration data onto case reporting in order to predict the future spread of epidemics. A great proxy for this data is anonymized metadata of cellphone calls (when and where they are made); unfortunately, this data is currently owned by large cellphone service providers such as Vodafone and Safaricom who have been unwilling to offer this data publically. Data they have released to researchers is only limitedly available and reflects metadata from multiple years prior as opposed to real-time data. As Wesolowski demonstrated in her proof of concept, cell phone metadata is able to accurately trace the spread of epidemics and being able to do so in real-time would provide an unprecedented view of future spreads of epidemics.

Ultimately, this platform represents a larger paradigm shift in the way that we look at how humanitarian aid is allocated that is occurring and will continue to occur in the next couple of decades where, as opposed to sending aid after the fact, we will be able to preempt situations, sending aid before it is too late as a preventative measure to regions that are likely to be impacted next. Real-time data on the location of cases, reported to a centralized system rather than via the long and onerous propagation chain through local officials and governments, will be crucial to this effort. Ultimately, the greater transparency that field doctors, nurses, nonprofits, governments, international organizations, and the general public have about current existing cases of epidemics, the more informed decisions each of these key stakeholders can make in response to the outbreak, reducing inefficiencies in resource and human allocation as well as the length of time it takes for us to respond to crises. In the meantime, there is still a significant amount of technological improvement that could be made, along the entire value chain of humanitarian aid delivery in epidemic situations.

Appendix 1: The site includes a heatmap of cases reported in real-time as well as a listing of the cases with information including the geographic location, number of cases, resistance, treatment, and strain of the case.



Appendix 2: The site is mobile accessible for on the ground analysis.



Appendix 3: Using Twilio integration, the site supports reporting of cases through text message input of case information. One submitted, the results populate to the site directly.